REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*

2. REPORT TYPE
Technical Papers

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE

Please see attached

5a. CONTRACT NUMBER
F04611-97-C-0064

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

5d. PROJECT NUMBER
4373

5e. TASK NUMBER
00NQ

5f. WORK UNIT NUMBER
346245

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Air Force Research Laboratory (AFMC)
AFRL/PRS
5 Pollux Drive
Edwards AFB CA 93524-7048

8. PERFORMING ORGANIZATION REPORT

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Air Force Research Laboratory (AFMC)
AFRL/PRS
5 Pollux Drive
Edwards AFB CA 93524-7048

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S NUMBER(S)
Please see attached

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

20030127 177

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
					Leilani Richardson
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. TELEPHONE NUMBER** *(include area code)*
Unclassified	Unclassified	Unclassified	A		(661) 275-5015

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. 239.18

Author(s): John Michael Fife

Circle name of presenter. If joint govt/contractor effort, what ___% work performed by the govt author?

Title: High Performance Hall Thruster Ground Demo

Source: In-House Project (AF 6.1/6.2/6.3/6.5) / Contract F04611-97-C-~~[illegible]~~ -0064 Other ___ SBIR (Y/N)

JON: 433300NQ Project Mgr/Div/Ext John Michael Fife / PRRS / 5-6792

Release Format: Abstract /Paper /Oral Presentation /VuGraphs/ Poster Session / Tech Report /Other

Security Classification: unclassified

If classified, classified by ______

Declassify on ______

Disclosure: Public Release /Limited Release/Foreign Release (See Table) ______

Forum/Audience: AIAA Space Technology Conference

Meeting Location and Date: Sept 28-30 Submission Deadline: Sept 28

Prior Release Authorization (insert PA #): ______ Date: ______

STINFO tracking number AFRL-PR-ED-TP-FY99-0182 Date assigned 27 Sep 99

High Performance Hall Thruster Ground Demo

Air Force Research Laboratory

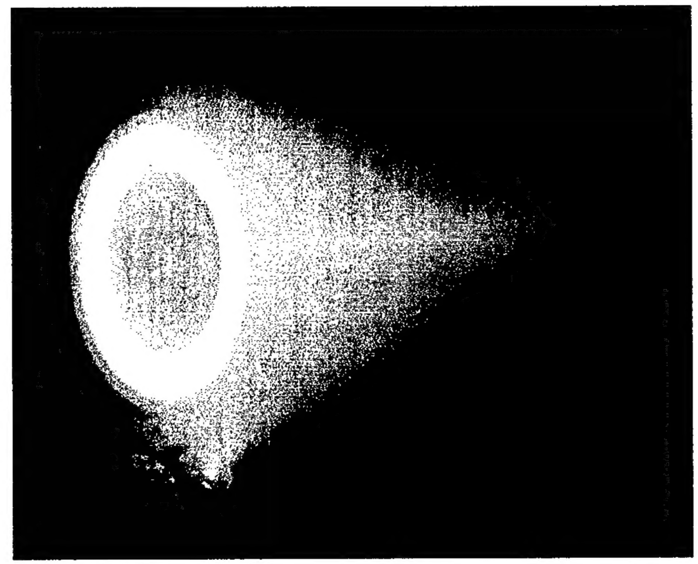
Spacecraft Propulsion Branch

Dr. John Michael Fife

September, 1999

Hall System
Outline

- Goal & Objectives
- Payoffs
- System Concept
- Milestones
- Hall System Development
- Summary
- Conclusions



Hall System Goals

OBJECTIVE: To develop and demonstrate the electric propulsion technology needed to meet the IHPRPT Phase I Goal

	Goal
Efficiency	**55%**
Life	**7200 hrs**
Specific Mass	**5.7 kg/kW**
Isp	**1801* seconds**

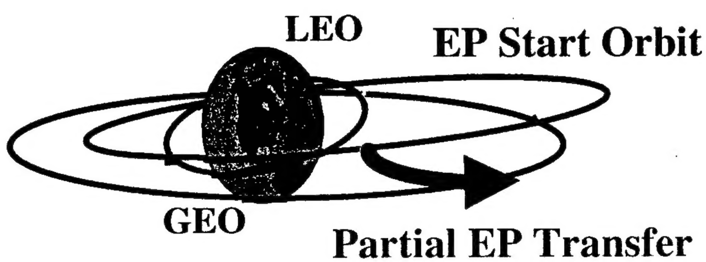
* 300 V PPU

Hall System Payoffs

Orbit Raising

Missions

- LEO Spiral Transfer (SBR, SBL)
- Apogee Insertion (GEO comm)



Spiral Transfer Payoffs (4 kWe):

- + 11 % LEO Atlas IIAS payload
- SBR to 850 km (121 Days)

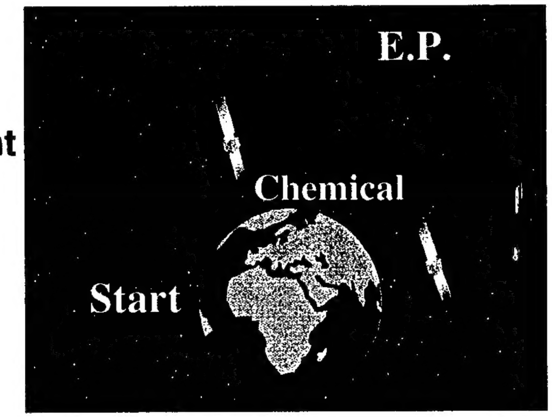
Apogee Payoffs (15 kWe):

- + 34% GEO Atlas IIAS payload
- $32 M Net launch Savings (105 Days)

Repositioning

Supports MAP deficiencies

- Repositioning Capability
- Recovery, repair, redeployment
- Global Mobility



Payoffs

- 17% less fuel or more moves (EP baseline)
- Faster move vs. chem

~ 2 X faster for same propellant mass

Stationkeeping

Mission

- GEO Communications

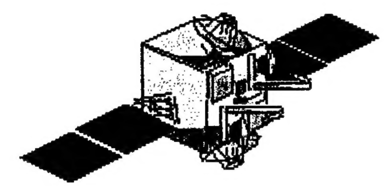
Payoffs

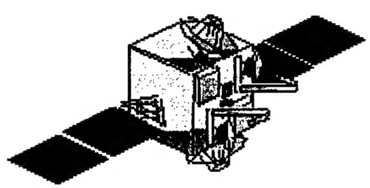
17% less fuel / more life (EP baseline)
13% less power for same thrust (EP baseline)

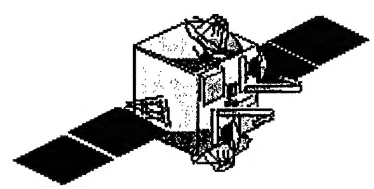
Hall System
Near Term Tech Transition Opportunity

MILSATCOM Advanced EHF

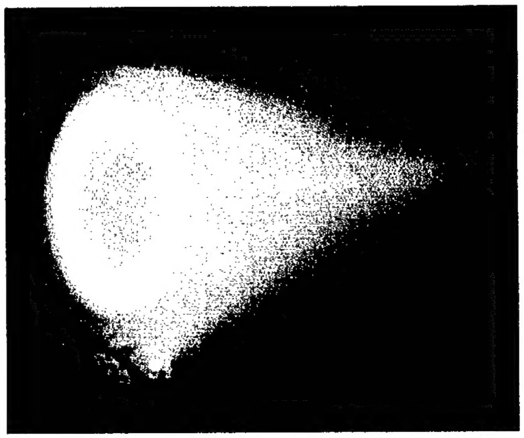
- Next Milstar System
- Approved Extended Duration Orbit Transfer
- Hall System Supports NSSK and Orbit Raising
- FY01 Tech Freeze
- FY06 Anticipated Launch



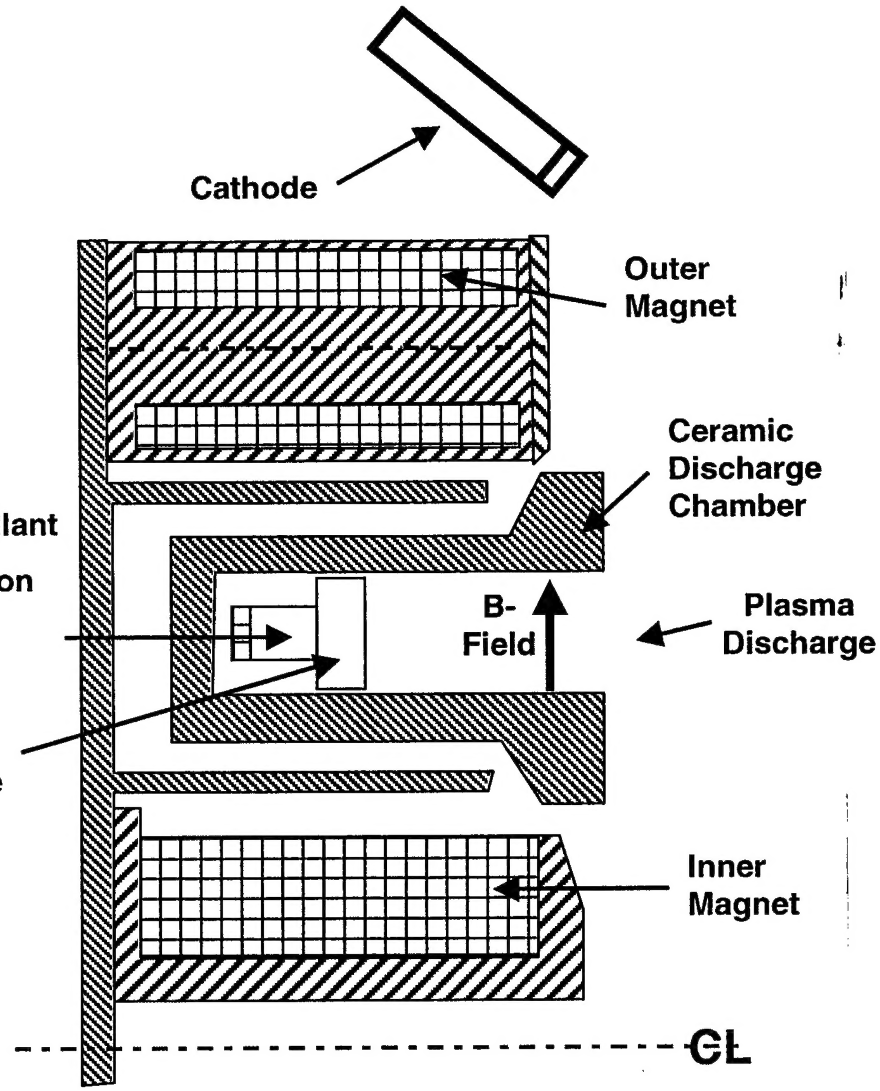




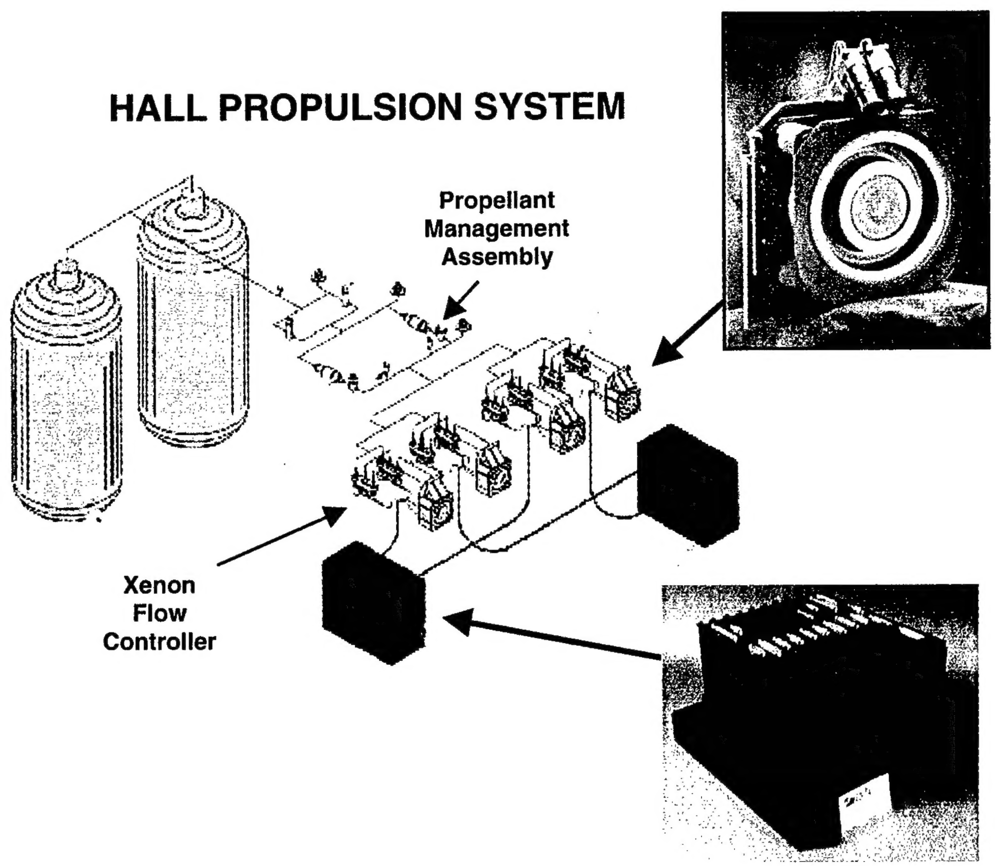
Hall System
Thruster Operation Background



1. Electrons emitted from the cathode travel toward the anode.
2. Electrons are impeded in the discharge channel by a strong radial magnetic field, causing a strong axial electric field to concentrate in this region.
4. This electric field heats the electrons, which subsequently ionize gaseous propellant (xenon) emitted near the anode.
6. The ionized gas accelerates axially through the electric field in the discharge channel, exiting the device at high speed, thus producing thrust.



Hall System Concept



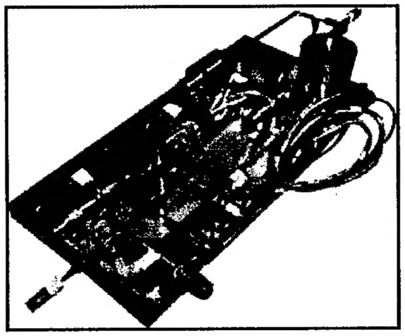
Current results: Isp = 1801, Effic = 58%

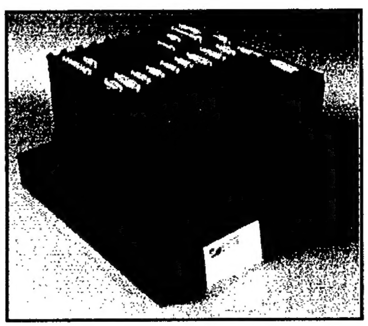
Current breadboard results: Effic > 94.4%

Hall System Integration

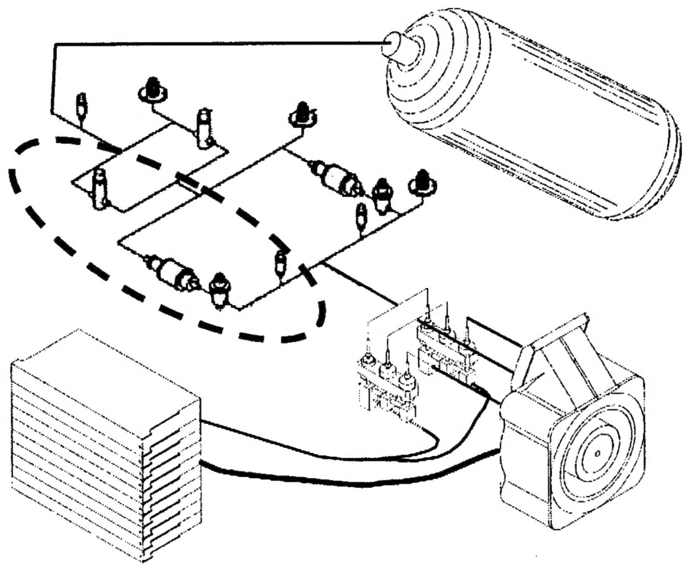
System demonstration hardware

Moog flight qualified PMA

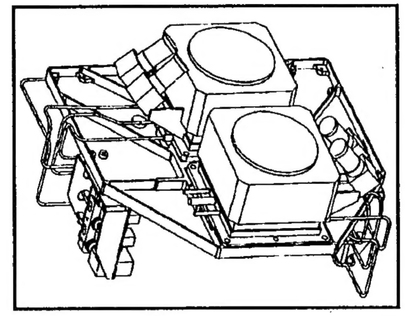


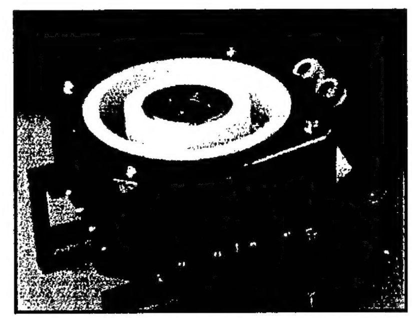


SS/Loral flight-like PPU
- non space rated parts



SS/Loral integration hardware





EDB/Fakel flight-like thruster
- qualification testing

System qualification level equivalent to SPT-100 flight qualification

SEQUA ARC

Hall Thruster System Program
Milestones

Project is Cost Shared

44% Paid by Contractor:

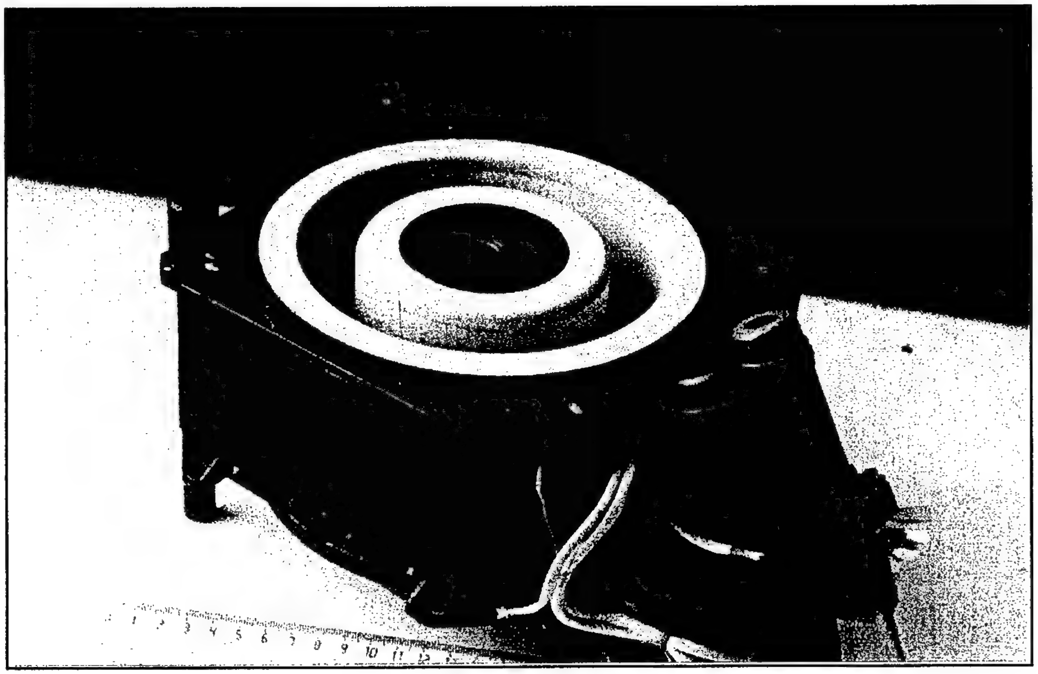
Atlantic Research Corporation

Date	Accomplishment
01/99	Phase I Thruster Development
01/99	PPU Breadboard Development
03/99	Thruster CDR
09/99	Thruster Performance, EMI, Contamination, Plume Testing in USA
10/99	PPU CDR
01/00	Thruster Thermal Integrated Test
01/00	PPU Thermal Integrated Test
02/00	System Integrated Functional Test
02/00	7200-Hour Life Test Begins at AFRL EP Lab
12/00	Project Complete
??/01	MILSATCOM Advanced EHF Tech Freeze
??/06	MILSATCOM Launch

■ **Completed**

■ **Not Yet Completed**

SPT-140 Demonstration Model Thruster



SPT-140 Demonstration Model (DM)

Power: 4.5 kW

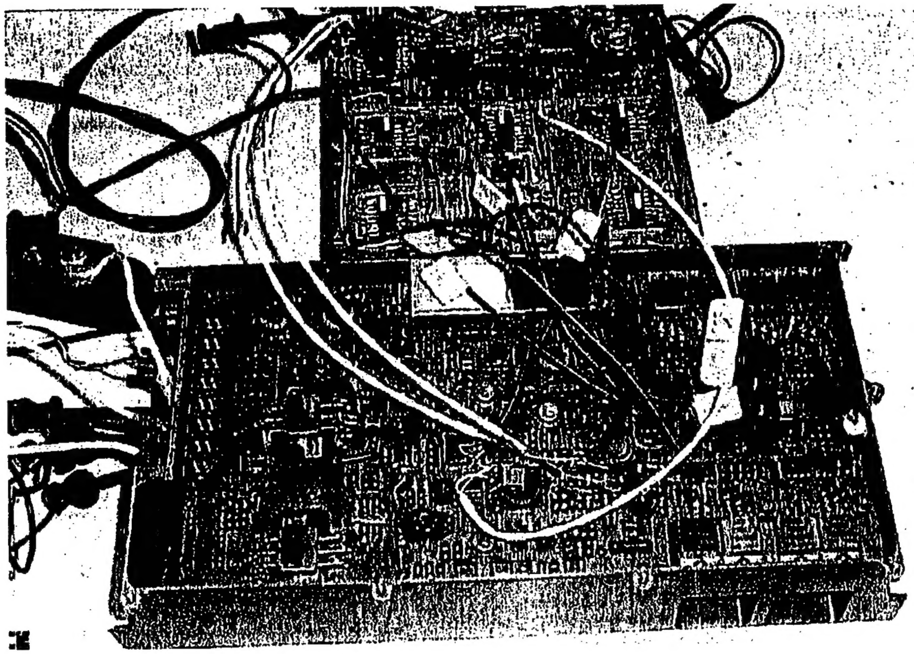
Thrust: 296 mN

Efficiency: 58%

Tests Completed:

- Vibration
- Shock
- Thermal Cycling
- EMC
- Performance
- Contamination
- >1100 hr firing

Hall System Anode Breadboard



PPU-140 Breadboard Anode Module

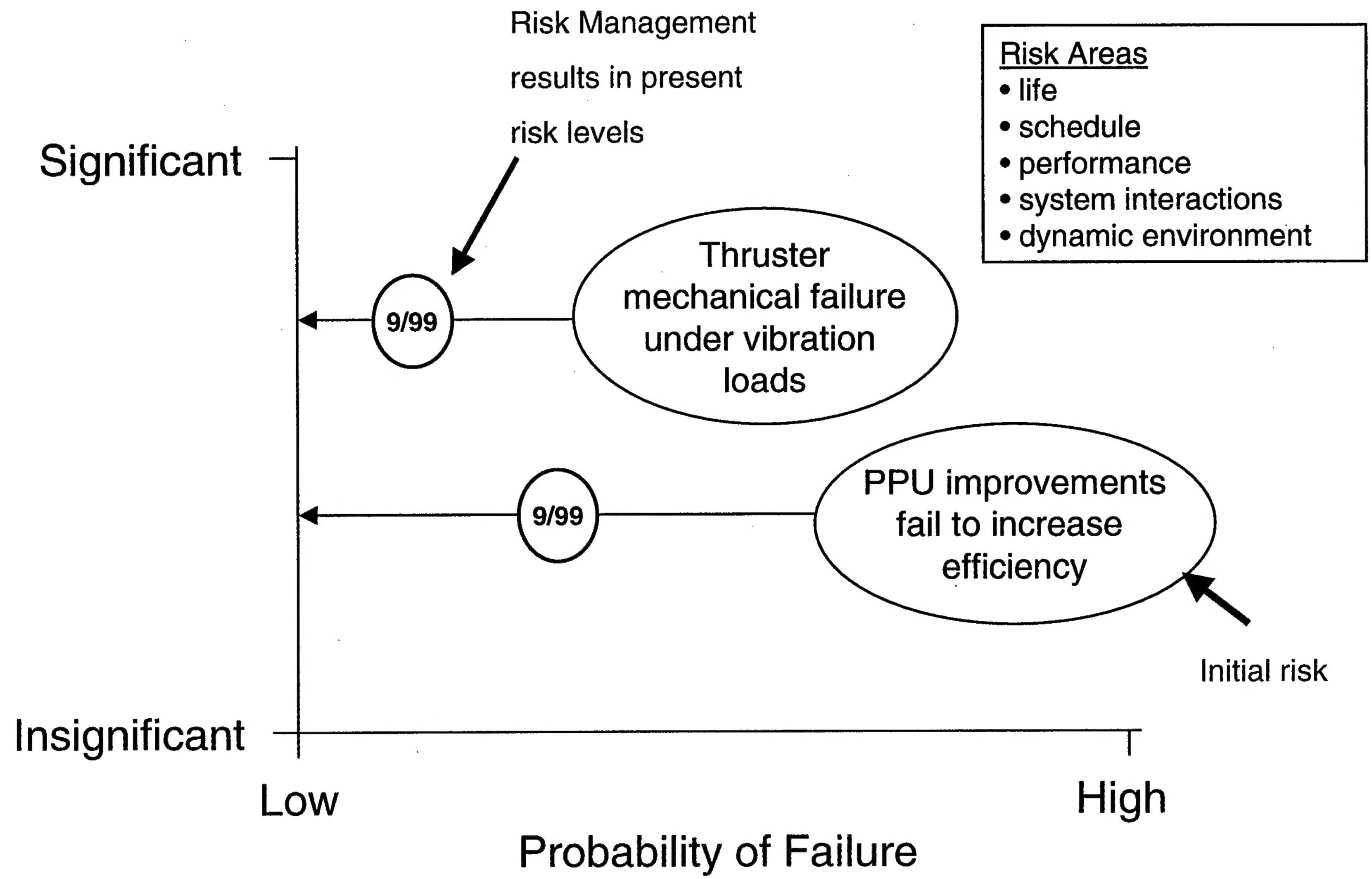
Power: 4.5 kW

PPU Mission Average Efficiency: 94.4%

Status:

- Breadboard Testing Completed
- Brassboard Anode Module Design Completed, Fabricated

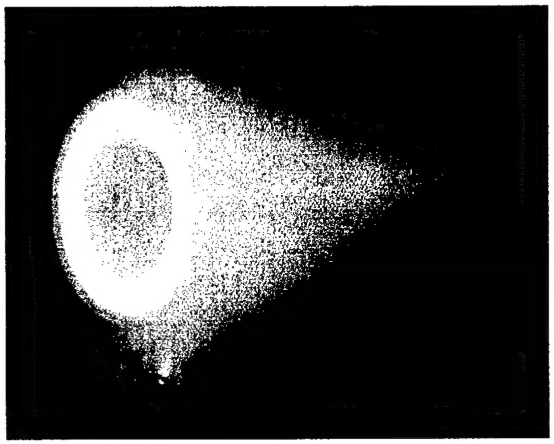
Hall System Risk Assessment



Hall System Summary

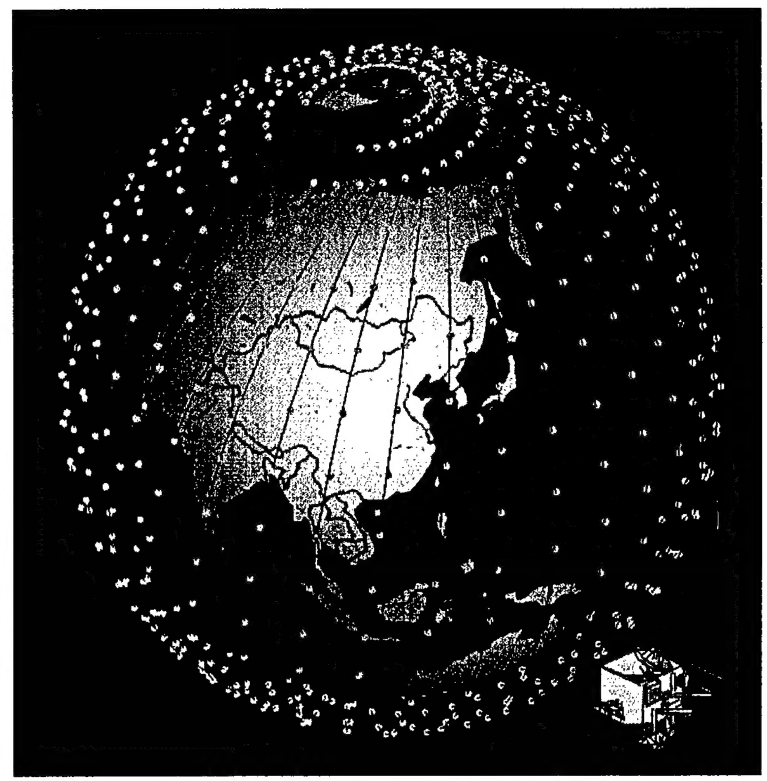
- Supports critical DoD missions
  - MILSATCOM Advanced EHF Opportunity
  - Orbit Raising, Repositioning, Stationkeeping
  - MAP Deficiencies
- Exceeds IHPRPT Phase I ES goal
- Demonstrates Flight Propulsion System

Hall System Conclusion



Future Military Constellation Opportunities
MILSATCOM Advanced EHF
GMTI & AMTI SBR to use 10-80 satellites

Efficient Orbit Raising ~ 100 days
+ 11% payload to LEO
+ 34% payload to GEO



Improved Stationkeeping
17% less propellant
than EP Baseline

Supports Mission Area Plan (MAP) deficiencies

- **Repositioning**
- **Recovery, Repair, Redeployment**
- **Global Mobility**